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EFFICIENCY AND QUALITY

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INCREASE OF GLASS MANUFACTURING EFFICIENCY USING CULLET IN FLOAT-GLASS PRODUCTION

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The effect of the quality of quality of a basic component (cullet) of batch on the final product (float-glass) is shown. The effect of the quality of cullet (the manufacturer's own and from outside suppliers) and the constancy of the amount of cullet loaded into the furnace on float-glass quality is analyzed. It is concluded that in order to supply high-quality cullet to glass enterprises in the Russian Federation centralized facilities for collecting and recycling float-glass cullet using advanced technology and high-capacity equipment must be built.

Key words: cullet, cullet specifications, defects in glass, recycling cullet.

In the world glass industry today, with continually increasing production volumes the use of cullet as a component of the batch is increasing. The main users of cullet as an addition to batch are container glass manufacturers.

The demand for cullet is increasing for a number of reasons. The molten-glass utilization factor (GUF) has increased considerably in connection with the use of advanced glass production lines. This has sharply decreased the availability of the manufacturer's own cullet and has required large material and energy expenditures as compensation. In European countries, the USA, and our domestic glass industry cullet usage in the production of glass containers reaches 70%. Questions concerning the use of large volumes of cullet are especially important today for solving environmental problems while reducing energy consumption and raw materials costs at the same time. A system for collecting and recycling cullet that meets container-glass industry requirements with respect to cleanliness (no impurity materials), chemical and granulometric compositions, and glass color has been organized abroad. In Russia work on organizing systems for collecting and recycling cullet to be used in the production of container glass is rudimentary.

Cullet in amounts to 20% is ordinarily used in float-glass manufacture. The cullet quality requirements (with respect to prescribed composition, presence of contaminants, and granulometric composition) for the manufacture of such glass must be more stringent than for container-glass manufacture. For all practical purposes, the collection and recycling of cullet suitable for float-glass production has not been organized in Russia.

Great importance is attached at the Salavat plant to questions of using the plant's own cullet (production and industrial-processing wastes) for float-glass manufacture.

Recycled cullet usage was about 20% after two new float-lines were put into operation; it is now 8 – 10%. This decrease is due to the GUF increasing to 90%, which resulted in a cullet shortage of the order of 5 – 10%.

A philosophy based on increasing the specifications for cullet as the main component of batch was adopted at the plant. Considerable attention was focused on questions of eliminating the factors responsible for contamination of cullet with by impurity materials (metallic, ceramic, plastic and packing materials). Magnetic separators were installed to decrease the content of equipment iron and other iron-containing impurities. In addition, adjustments were made to the granulometric composition and work was performed on utilizing the heat contained in the exhaust gases to heat the cullet, adjusting the batch – cullet mixing regime with additional wetting of the batch and cullet with hot water, and obtaining a uniform distribution of the resulting mixture over loading front of the batch and cullet being loaded into the furnace.

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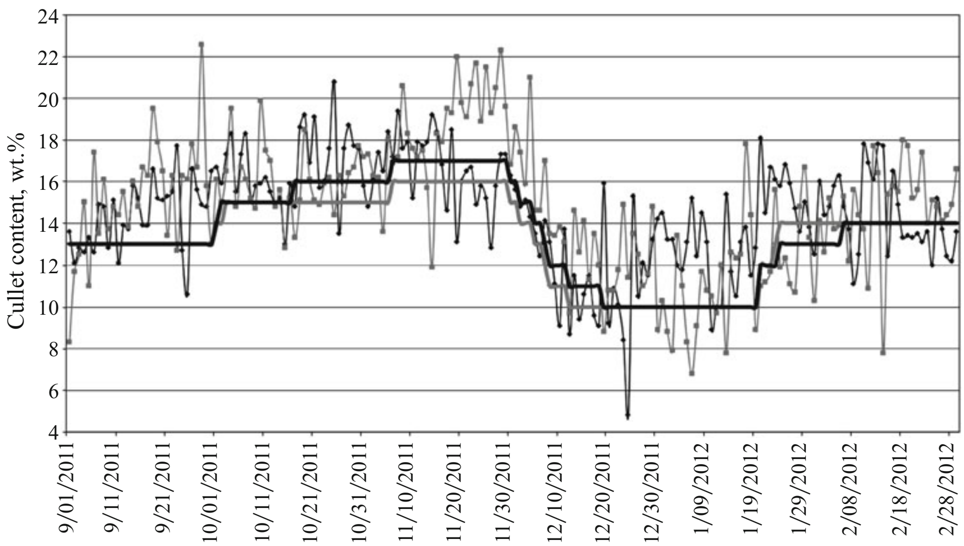

Fig. 1. Variation of cullet amount in the molten glass: ◆) loaded cullet content in line No. 1; ■) same in line No. 6; ——) prescribed cullet amount for line No. 1; ——) same for line No. 6.

As a result the optimal granulometric composition of the cullet was taken to be 50% granules of size 3 – 10 mm.

A technological feature of great moment for the production of high-grade sheet glass is maintaining a prescribed ratio of the amounts of batch and cullet loaded into the furnace. However, deviations from the prescribed regime occur in a number of cases for the following reasons.

The plant cannot create the required stores of cullet as a buffer because of the shortage of cullet. This makes it necessary to periodically change the amount of cullet loaded (Fig. 1), which in turn disrupts the operation of the electronic equipment in the system maintaining the batch : cullet ratio at a constant level (see Fig. 1).

This makes it necessary to use cullet from outside suppliers (and even from float-glass recyclers at the Salavat plant) to build up the required stores in the absence of specialized cullet preparation at the plant. As a result the molten glass becomes contaminated and cannot be used.

Analysis of the periods during which cullet from outside suppliers is used showed an increase in the number of characteristic defects on glass ribbon (Fig. 2), which, correspondingly, lowered the GUF and the quality of the final product.

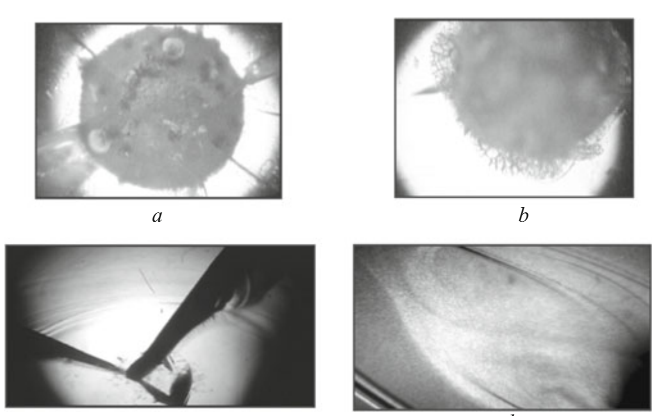

Fig. 2. Defects in glass due to the contamination of cullet (×100): *a*, *b*) inclusions; *c*, *d*) striae.

Two types of defects appearing in glass as a result of the use of contaminated cullet are inclusions (Fig. 2*a* and *b*) and striae (Fig. 2*c* and *d*). Dark grey inclusions are seen on glass ribbon. They have a characteristic spherical shape and dense structure, appear on the top surface of the glass and are accompanied by high stresses, which cause the glass to fracture.

Examination under a microscope has shown that the main components of the inclusions are silica and its modifications (tridimite, cristobalite), which are the products of polymorphic transformations. Fine bubbles with rounded, extended shape occur on the surface of and around inclusions. The dimensions of the defects are 1360×960 and 878×834 μm. Defects are products of the action of strong reducing agents on silica in sand.

Striae look like surface distortions against the background formed by the surrounding glass. Under a microscope striae are nodal, rough and twisted striations, round which sharply expressed stresses are observed. No crystalline formations or bubbles are observed.

In most cases striae and inclusions are due to cullet contaminated with impurities enters the melt. This supposition is based on the fact that the defects indicated above periodically appear on the glass ribbons of the No. 1 and No. 6 lines simultaneously.

A considerable spike (increase) in the number of inclusions occurs during the period when the cullet obtained from outside suppliers contains contaminants, especially glass wastes from the production of glass packages, is used for making glass (Fig. 3).

The GUF is higher in float-line No. 1 than in line No. 6, and a larger quantity of cullet obtained from outside suppliers is loaded into the furnace in line No. 1 to compensate for

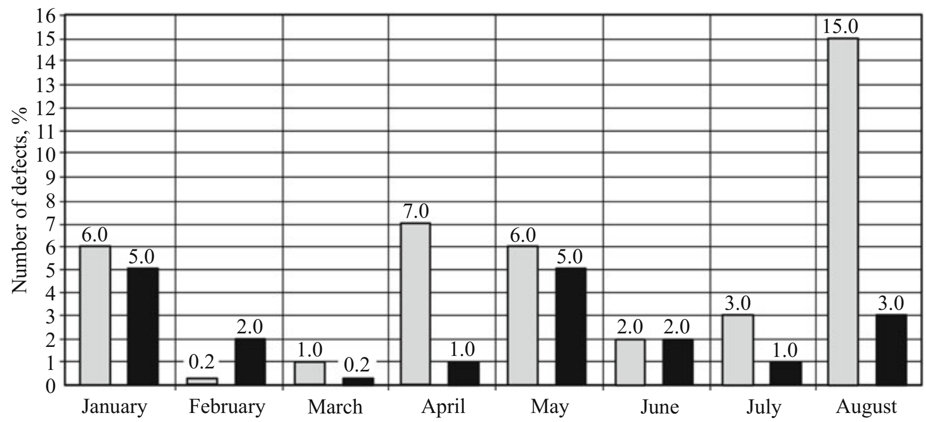

Fig. 3. Quantitative distribution of spherical inclusions in float-lines: □) line No. 1; ■) line No. 6.

the shortage of recycled cullet. This explains the higher background level of spherical inclusions in line No. 1.

Since January 2012 cullet delivered in railroad cars has been rejected at the Salavat plant. Now these inclusions comprise no more than 1%.

Deviations from stable feeding of cullet into a glass-making furnace create the same disruptions of the technological regime of glassmaking as do changes in the position of melting boundaries, disruptions of the temperature regime in the gas medium and molten glass; they also cause fluctuations in the amount of fuel expended on glassmaking and changes in the redox potential of the molten glass and the ratio of bi- and trivalent iron oxides.

The work performed at the Salavatsteklo plant on the use of cullet confirms that in principle colorless float-glass cullet can be used to organize efficient operation of glass furnaces and to obtain high-grade product.

At the same time it has been conclude that it is necessary to develop centralized facilities for the collecting and recycling float-glass cullet. Analysis of the composition of float-glass from different manufacturers in the Russian Federation (see Table 1) has shown that all compositions are similar, which makes it possible to use recycled cullet in all plants producing float-glass.

TABLE 1. Comparison of the Chemical Composition of Float-Glass from Different Manufacturers in the Russian Federation

Glass manufacturer	Content, wt.%						
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	SO_3
No. 1	71.64	0.62	0.098	9.03	4.10	13.98	0.22
No. 2	71.06	1.18	0.118	8.72	4.37	14.10	0.26
No. 3	71.44	0.87	0.072	9.24	0.72	13.37	0.22
No. 4	72.48	1.06	0.079	8.86	3.66	13.34	0.40
No. 5	72.74	1.16	0.074	8.82	3.68	13.05	0.37

However, it is necessary to take account of the fact that stuff dyed sheet glass, coated glass, reflective glass, mirror fabric and other types of glass cannot be used as cullet for manufacturing colorless glass.

It is especially important to note that the specifications for the quality of recycled cullet must not be lower than that those for main raw material used to make batch in float-glass production.

The need to develop centralized facilities for recycling float-glass using advanced technology and high-capacity equipment in order to supply high-quality cullet to glass enterprises in the Russian Federation has now come to a head.